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A Bacteriological Survey of Buctouche Bay (New Brunswick Shellfish Area #6)

Atlantic Region
Surveillance Report
EPS-AR-77-9

A BACTERIOLOGICAL SURVEY OF BUCTOUCHE BAY
(NEW BRUNSWICK SHELLFISH AREA 6)

by

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ABSTRACT

This report presents and summarizes the results of sanitary, bacteriological and hydrographic studies of Buctouche Bay and its watershed during the period of August 3 to September 25, 1976. Fecal coliform numbers in Buctouche Bay varied widely and were relatively low in the outer sector of the Bay. Median fecal coliform counts in the approved sector of the Bay was satisfactory in terms of shellfish growing water standards under low rainfall and dry conditions. Evidence is presented that there are significant sources of fecal pollution on the watershed of Buctouche River and that runoff during heavy flow conditions could contribute substantial quantities of fecal coliforms to the estuary. Shellfish growing standards will be exceeded in a portion of the open area following significant storm events (1.0 inches/24 hrs.). In spite of the various bacterial inputs to the streams in the Buctouche watershed, the relatively low volume stream flow had no demonstrative effect on the numbers of fecal coliform in the waters of the Buctouche Bay during the dry weather period in August and September.

It is concluded that the recommended closures on Buctouche Bay and the Little Buctouche River should remain unchanged under normal conditions of rainfall. However, following major rainfall events (>1.0 inches/24 hrs.) a portion of the open area may require closure for a period of seven days. A new closure is recommended for Black River, upstream from the highway bridge.

Resumé

Ce rapport présente les résultats des études sanitaires, bactériologiquès et hydrographiques de la baie de Buctouche et son versant pendant la période du 3 aôut au 25 septembre, 1976. Les comptes de colibacilles fécaux dans la baie de Buctouche varient grandement et étaient rélativement bas dans la section extérieure de la baie. La médianne des comptes de colibacilles fécaux dans le secteur approuvé de la baie était satisfaisante en vue du norme pour les eaux coquillières suivant les conditions sèches. L'évidence est présentée qu'il y a des sources significatives de pollution fécale sur le versant de la rivière Buctouche et que le ruissellement pendant des périodes de gros flux peut contribué une quantité significative de colibacilles fécaux à l'estuaire. L'étendard pour les zones coquillières sera dépassé dans une portion du secteur maintenant ouvert suivant des chutes de pluie significatives (1.0 pouce/24 heures). Malgré les additions divers de bactéries aux ruisseaux du versant de Buctouche, les flux des ruisseaux relativement bas n'ont pas eus un effet démonstratif sur le compte de colibacilles fécaux dans la baie de Buctouche pendant les périodes sèches d'aôut et septembre.

Il est conclus que les fermetures recommendés pour la baie de Buctouche et la petite rivière Buctouche doivent resté en effect suivant les conditions de pluies normales. Cependant, suivant des chutes de pluies majeures (>1.0 pouce/24 heures) une portion du secteur ouvert peut avoir besoin d'une fermeture pour une période de sept jours. Une nouvelle fermeture est recommendée pour la rivière Black en amont du pont.

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Secteur maritime

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1 INTRODUCTION

A bacteriological survey of the water quality of Buctouche Bay and watershed was conducted during the months of August and September, 1976, as recommended by the Maritime Standing Committee on Shellfish. The purpose of this study was to define the adequacy of the recommended shellfish closure by Baxter and Julien, 1976[4], and to determine whether a conditional closure is needed in the area following periods of heavy rainfall. Sampling schedules were so arranged as to obtain samples representing dry and heavy runoff conditions at different tidal phases.

An earlier survey of Buctouche Bay[4] indicated that the bacteriological water quality of the bay was excellent in dry conditions. However, the fecal coliform levels in the area were governed by rainfall conditions as shown in previous survey data. In 1976, significant increases of fecal coliform densities were observed in the bay up to three days after periods of heavy rainfall greater than two inches.

2 MATERIALS AND METHODS

2.1 Sampling Schedule

Water samples were collected in sterile glass bottles from 16 sites established at Buctouche Bay and from 23 streams flowing into the Buctouche estuary (Figure 1 & 2). All samples collected were kept in a cooler and transported immediately to the bacteriological mobile laboratory located at Buctouche for analysis.

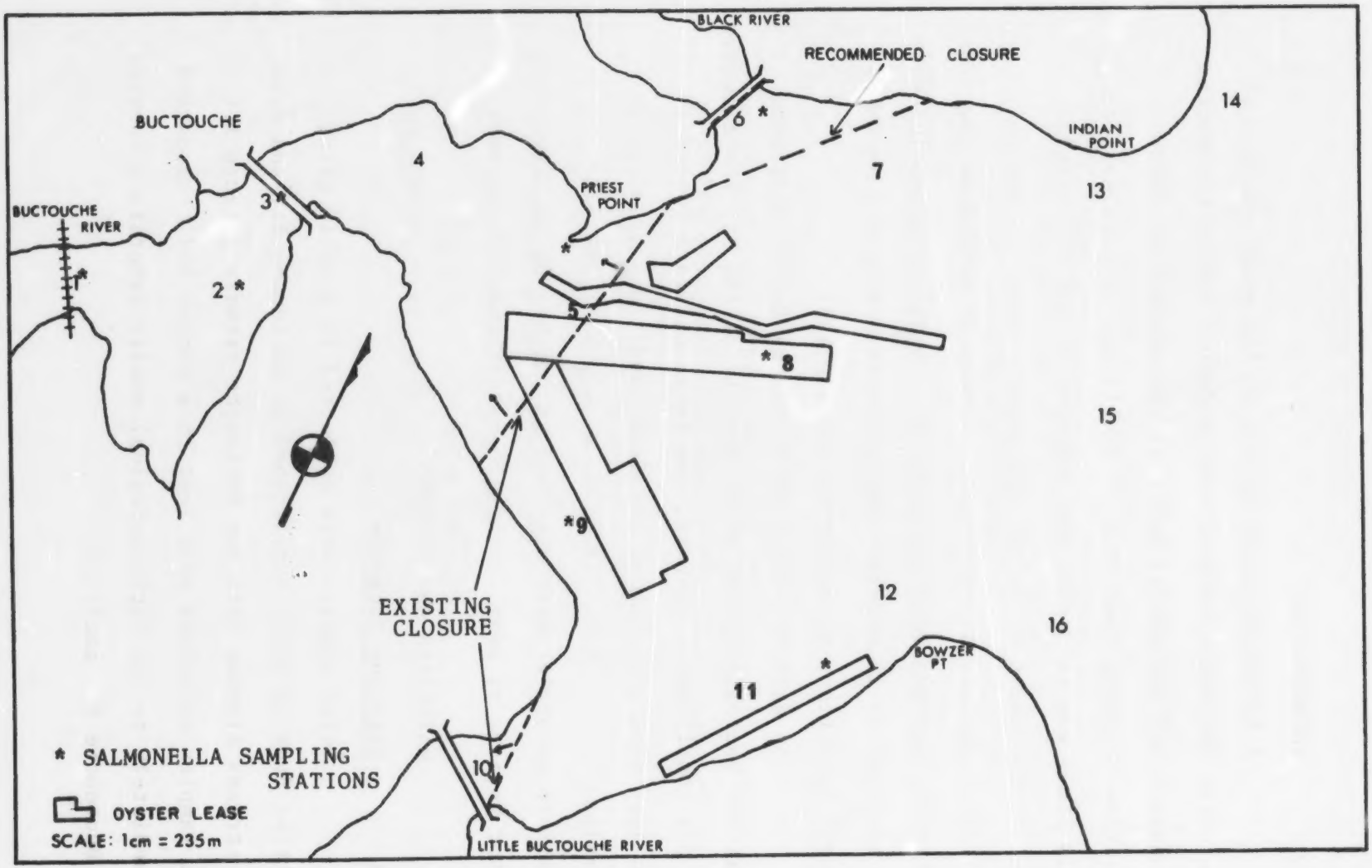

FIGURE 1 - LOCATION OF SAMPLING STATIONS AND OYSTER LEASES IN BUCTOUCHE BAY, 1976

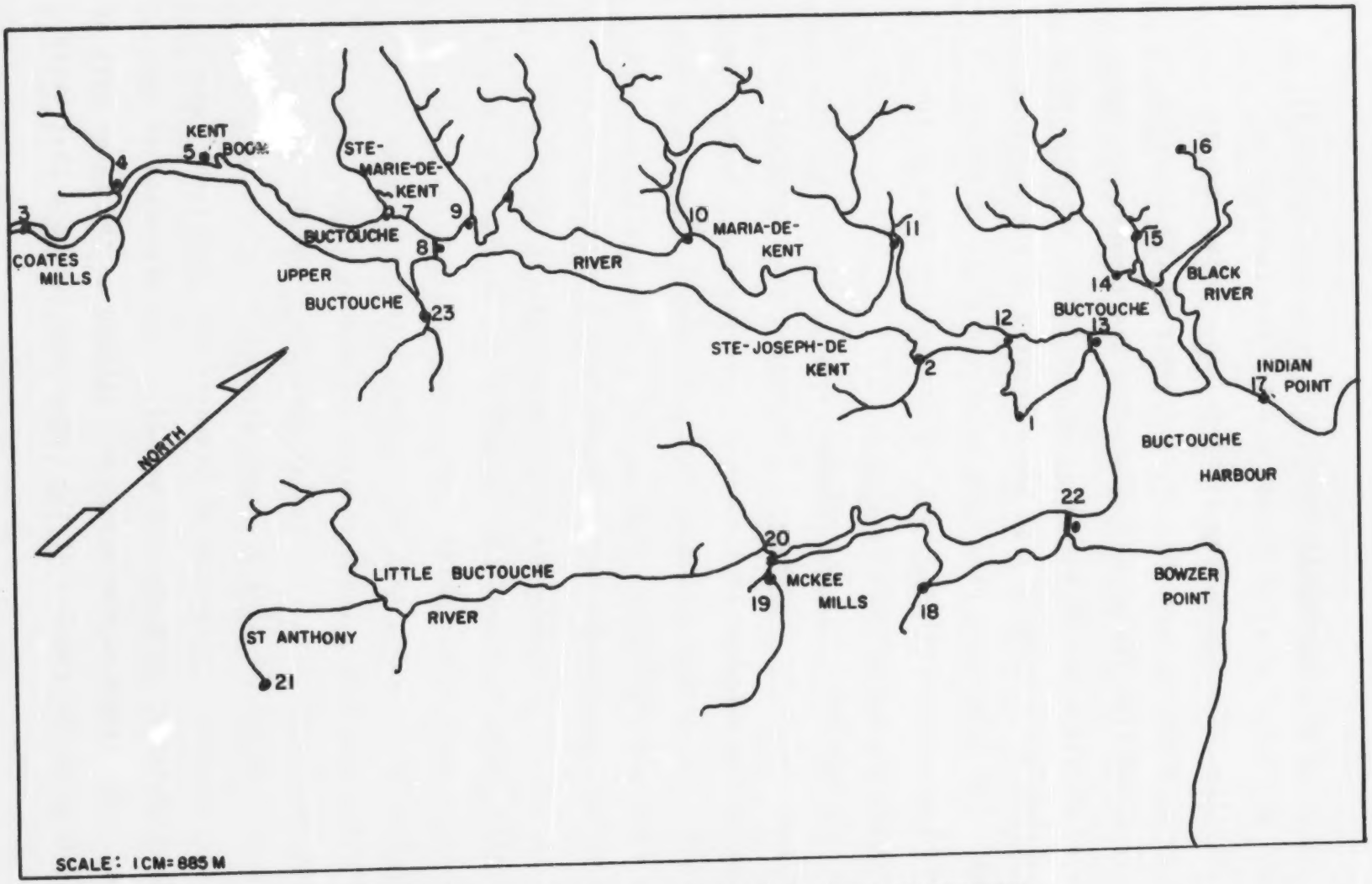

FIGURE 2 - LOCATION OF SAMPLING STATIONS IN BUCTOUCHE RIVER WATERSHED

Eight Salmonella collecting pads were placed at eight pre-selected sites in the bay for the recovery of Salmonella. The collecting pads are made of two packets of gauze attached to a 30 x 30 cm. square of chicken wire. The pad and wire frames are wrapped in kraft paper and autoclaved at 121°C for 15 minutes. In the field, the pads were unwrapped and suspended from buoys located in the sampling area. The collecting pads were retrieved after 72 hours, placed in sterile plastic bags and transported back to the mobile laboratory for processing.

2.2 Bacteriological Analysis

2.2.1 Bacterial indicators. Because of the intensity of the sampling schedule in this study, the rapid A-1 method was used for the determination of fecal coliforms. The A-1 method was developed by Andrew and Presnell[3] and requires only 24 hours for processing. Water samples were pipetted directly into A-1 medium in three decimal dilutions using five tubes per dilution. The inoculated tubes were first incubated in an air incubator at 35°C for three hours before being transfered directly into a water bath maintaining a temperature of 44.5 ± 0.2°C for 21 hours. Tubes showing any amount of gas after 24 hours incubation were recorded as positive. The MPN method as described in the APHA Standard Methods Procedure for the Bacteriological Examination of Seawater and Shellfish[1] was used in parallel with the A-1 method in the beginning of the study. The standard MPN method was deleted in the later part of the study as the results of the comparison indicate that there

was no significant difference between the two methods in fecal coliform recovery.

Fecal streptococcus densities were determined by the membrane filtration technique as described in APHA Standard Methods for the Examination of Water and Wastewater[2]. The growth medium used was m-enterococcus agar (Difco).

2.2.2 Salmonella isolation. One packet of gauze from each collecting pad was transfered aseptically into a flask containing 300 ml. of tetrathionate broth which was pre-warmed to 41.5°C. The other packet of gauge was placed into a flask containing 300 ml. of selenite broth. All enrichment broths were incubated at 41.5°C for 22 hours. The enrichment broths were then streaked on XLD Agar Taylor and Brilliant Green Agar plates and incubated at 41.5°C for 22 hours. Colonies resembling Salmonella were picked from the streak plates, purified and inoculated into Triple Sugar Iron Agar (TSI), Urea Agar, Motility Sulfide Medium, KCN Broth and H Broth and incubated at 35°C for 22 hours. All suspected Salmonella colonies were confirmed by further biochemical and serological tests.

2.2.3 Biochemical identification of fecal coliform isolates. All gas-positive tubes from selected stations were streaked on Levine eosine methylene blue (EMB) agar plates and incubated at 35°C for 24 hours. Representative colonies of each type were picked and transfered to lactose broth and incubated at 35°C for 24 and 48 hours. All cultures from gas-positive lactose tubes were subjected to Indole, Methyl-Red, Voges-Proskauer, Simmons Citrate Agar, Motility Plates (20°C and 35°C), TSI and Ornithine Decarboxylase tests.

2.3 Physical Parameters

Water temperature and salinity was measured *in situ* using a Beckman salinometer. Rainfall and wind records for the Buctouche Bay area were obtained from the Provincial Department of Forestry and the Atmospheric Environment Service, Environment Canada. Surface current in Buctouche Bay were measured by a current meter set up at two locations for several days during the study period.

3 SANITARY SURVEY RESULTS

3.1 Buctouche River

Sources of fecal contamination on the Buctouche River include the villages of Buctouche,Ste. Marie de Kent and numerous point and non point sources of domestic and agricultural wastes scattered along the length of the estuary. The village of Buctouche (pop. 2900) is located at the mouth of the estuary. Approximately 40% of the domestic wastes of the village are collected and treated in a 4 acre single cell lagoon, built in 1966 and located between the Railway bridge and highway 11 bridge. Flow from the lagoon is estimated at 120,000 IGPD and the system is overloaded (Donnelly 1975)[5]. A number of other important point sources of sewage in the village have been previously identified (Donnelly, 1975, Baxter and Julien, 1976).

The village of Ste. Marie de Kent, located approximately 6 miles from the estuary mouth is served by septic tanks and tile field systems. There is a lagoon at

Mount Carmel Bridge which was constructed in 1966 and serves the regional school and exhibition ground. A few point sources of sewage were observed entering the river from homes near Mount Carmel Bridge.

A single day's observation noted approximately 635 head of livestock on the land adjacent to the river between Buctouche and Coates Mills. Many of these were noted in the Coates Mills - Mill Creek sector of the estuary. Of particular importance was obvious drainage from a manure pile to a brook (site 7) just west of Ste. Marie de Kent as well as a number of animals on sloping land near the mouth of Mill Creek (site 10) and at site 23.

3.2 Little Buctouche River

The major population on Little Buctouche River is limited to farms and homes scattered along the watershed and the village of St. Anthony. The village of St. Anthony is the major population center with population of approximately 756 located 7 miles upstream from the Bay. Wastes from the town are collected and discharged to a 3.5 acre lagoon installed in 1966. Recently a second lagoon of similar size has been installed adjacent to the original lagoon. At present these lagoons are not interconnected and the original lagoon still receives most of the village's wastes and appears to be overloaded. On the other hand the new lagoon appears to serve only a limited number of new homes and is greatly underloaded. The separate discharges of both lagoons enter Smelt Brook which discharges to the Little Buctouche River at McKee Mills.

The other major source of contamination on the River appears to be limited to farming activities. In total approximately 270 head of cattle were observed on land adjacent to the River between St. Anthony and the Bay. Cattle were noted in the northern side of the River 1.9 miles upriver and most were noted at McKee Mills and just above McKee Mills, 2.9 - 4.0 miles upstream from the Bay. There are also several individual discharges at St. Francois de Kent at the mouth of the River.

3.3 Black River

The contamination sources on the Black River include scattered point sources and farming activity. Probable point sewage sources were noted at the mouth of the River. In total, approximately 115 head of cattle were observed on the watershed. Some of these were noted on the main stream, 1.8 miles upriver and the remainder at Girouardville on George Collet Brook, approximately 2 miles from the mouth of the Black River. Several point sources of potential sewage discharge were also noted along highway 11.

4 PRECIPITATION RESULTS

Bacteriological results of this study represent conditions of precipitation ranging from 0 - 0.88 inches per 24 hours. The precipitation data is given in Appendix Table 1. Storm events which were monitored included events of 0.37, 0.5, 0.5 and 0.88 inches of rain in 24 hours.

Of particular interest is the expected frequency of such events based on historical data. A probability curve of daily rainfall for the month of August, September and October has been

constructed from data collected at Rexton for the 1971-1975 period (Figure 3). From this curve the probable frequency of rainfall in excess of selected 24 hr. levels can be estimated.

The frequency of rainfall events equal to or greater than 0.5, 0.88 and 1.0 inches per 24 hrs. were determined as 6%, 2.5%, and 2.25% of days respectively for the three monthly day periods of August, September, October (individual differences in these probabilities between months, at the levels of interest are negligible). These correspond to 1.86, 0.77 and 0.63 days respectively in any 31 day period as shown in Figure 3. The probable frequency rainfall events in a 48 hour period are also plotted in Figure 3 for comparison purposes. The observed frequency of selected 24 hr. rainfall events, for the months of September and October, in the last five years are given in Table 1.

TABLE 1 FREQUENCY OF OCCURRENCE OF SELECTED STORM EVENTS DURING SEPTEMBER AND OCTOBER, 1971-1975

Storm Event Rainfall Inches/ 24 hrs.	Month	YEAR 1971	1972	1973	1974	1975	Total
>1.0"	Sept.	0	0	1	1	1	3
	Oct.	1	1	0	2	0	4
	SUBTOTAL	1	1	1	3	1	7
>0.5"	Sept.	0	2	1	5	2	10
	Oct.	1	3	0	4	2	10
	SUBTOTAL	1	5	1	9	4	20

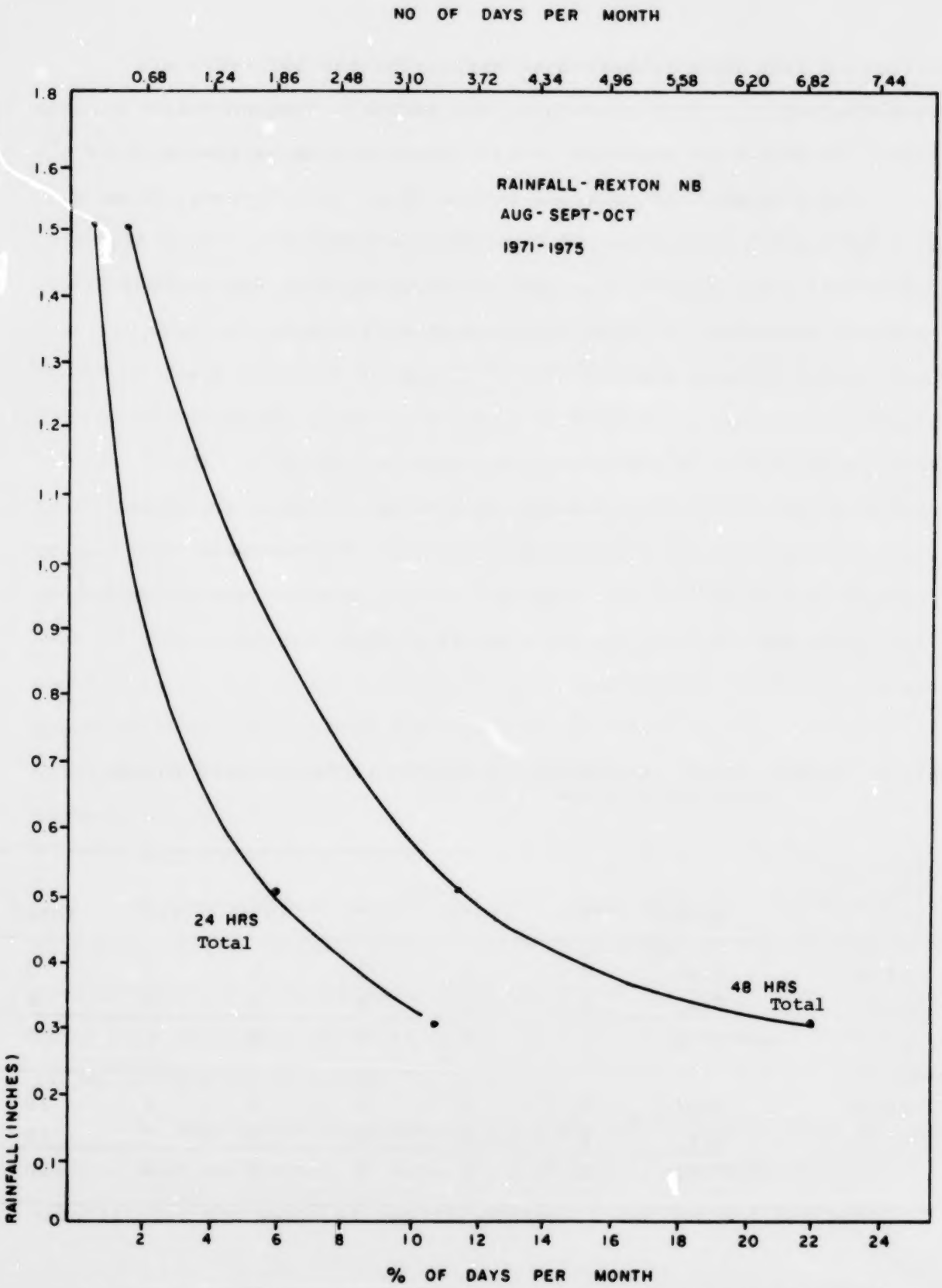

FIGURE 3 - FREQUENCY OF RAINFALL AT REXTON FOR 1971-1975 PERIOD

Table 1 shows that rainfall levels in excess of 1.0 inch per 24 hrs. occurred seven times in the last five years during the September - October period.

A probability curve of the maximum 24 hr. rainfall levels observed for a fifty year period at Rexton is given in Figure 4. From this curve it is estimated that 95% of the maximum 24 hr. rainfall events will be equal to or less than 2.75 inches.

5 HYDROGRAPHIC RESULTS

5.1 Currents

The direction and velocity of surface currents were measured at Stations 2 and 5 for several days each during August. A portion of this data is presented in Figures 5 and 6. Surface water movement at Station 5 at the closure line, exhibited maximum velocities of 3.36 mph. on the rising tide and 6.04 mph. on the falling tide. These measurements represent a maximum tidal differential of 1.3 feet as compared with the predicted maximum differential for the area of 1.9 feet. Current velocities at Station 2 reached a maximum of 0.56 mph. on the rising tide and 2.24 mph. on the falling tide during dry weather conditions. Maximum tidal amplitude was minimal >0.7 during the period of measurement. Following 0.31 inches of rain on August 10, initially, surface velocities increased, reaching 4.47 mph. on the falling tide. On the subsequent tidal changes the surface current remained as an outfall of <0.56 mph., which obliterated rising tide figures. The time of travel for effluent leaving the present lagoon to reach the closure line (Station 5) is approximately 20-30 minutes. This estimate is probably the maximum and time of travel is probably reduced significantly during low flow periods and or more extreme tidal amplitudes.

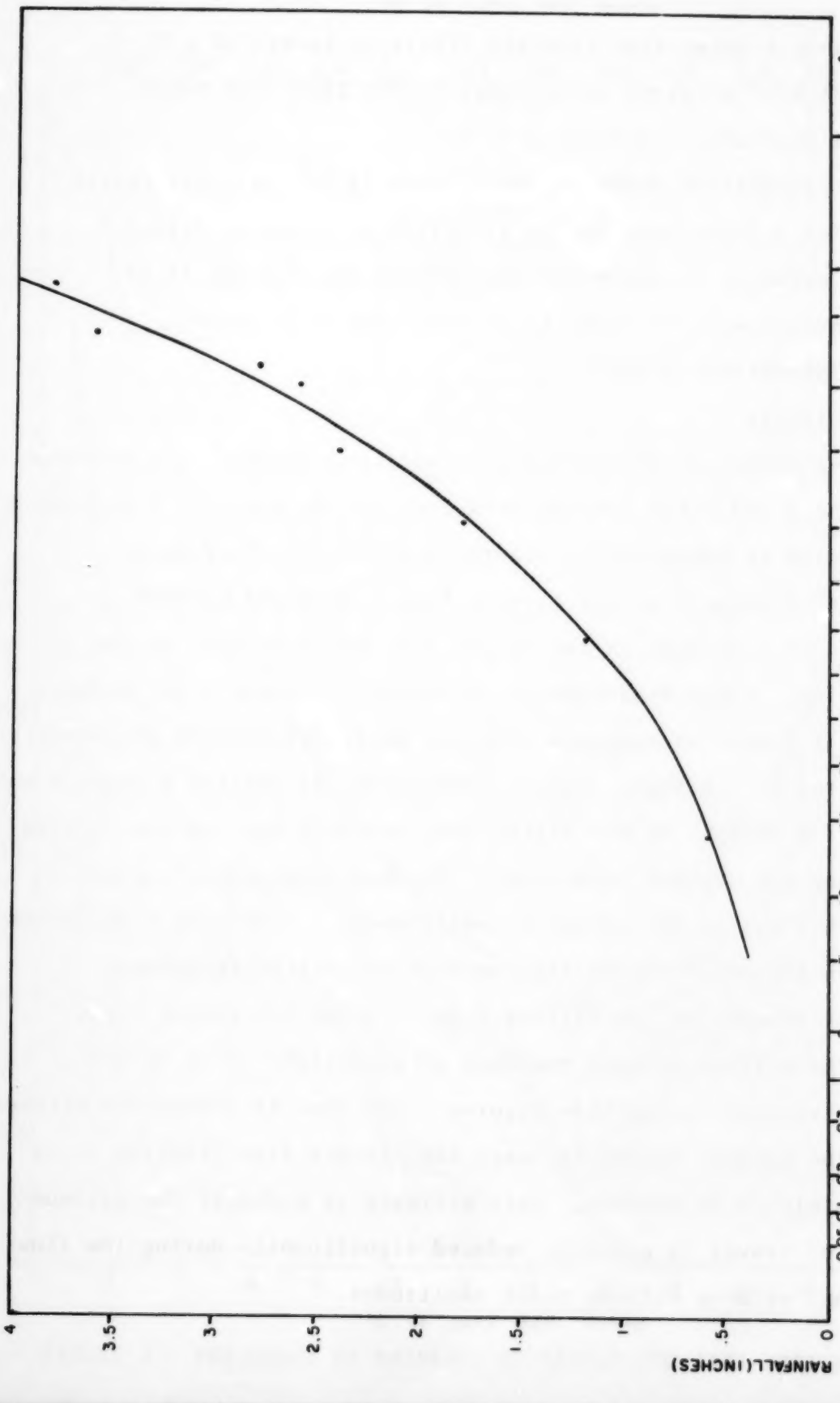

FIGURE 4 - MAXIMUM RAINFALL IN 24 HOURS AT REXTON (1922-1972)

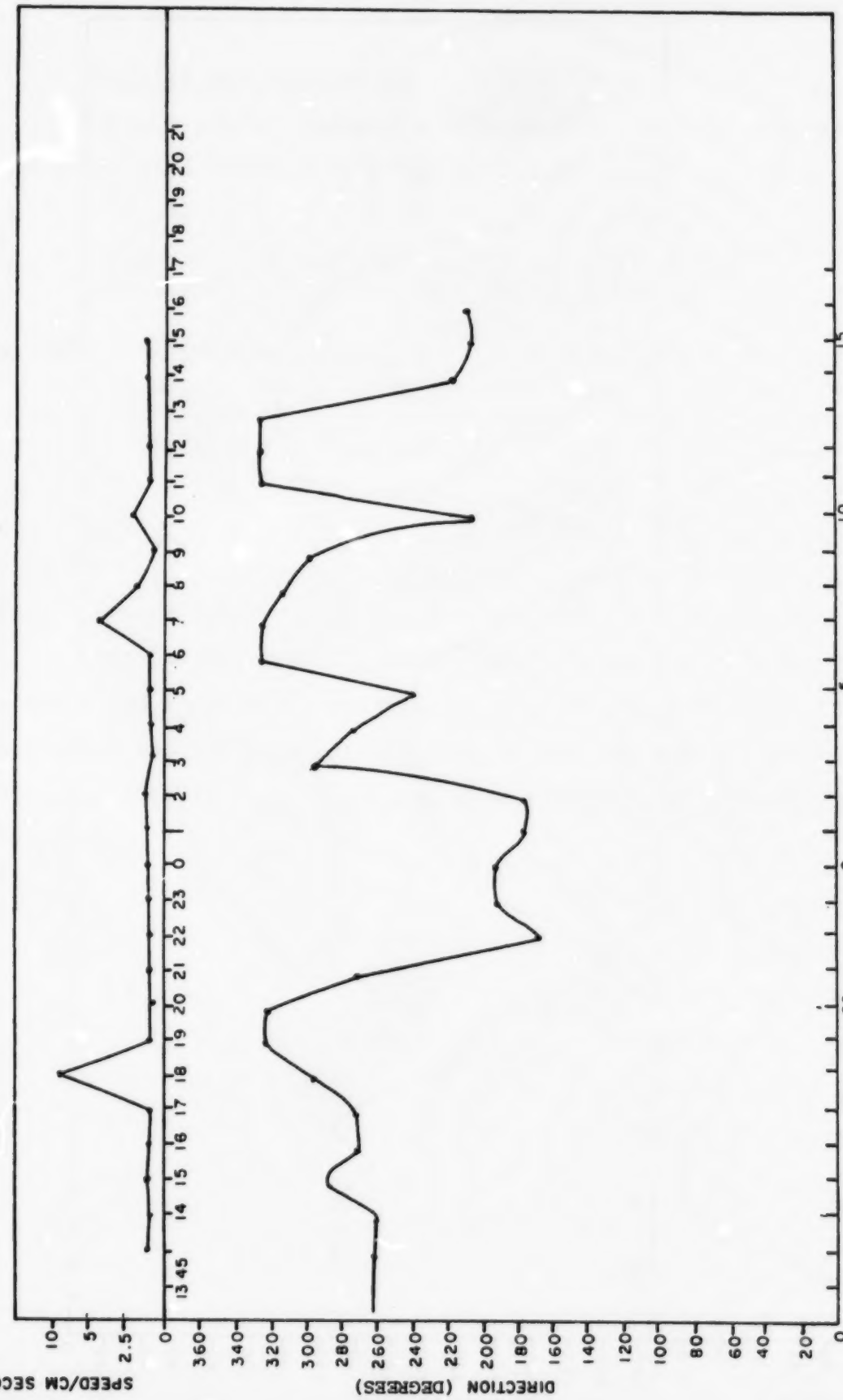

FIGURE 5 - DIRECTION AND VELOCITY OF SURFACE CURRENTS AT STATION 2, BUCTOUCHE BAY

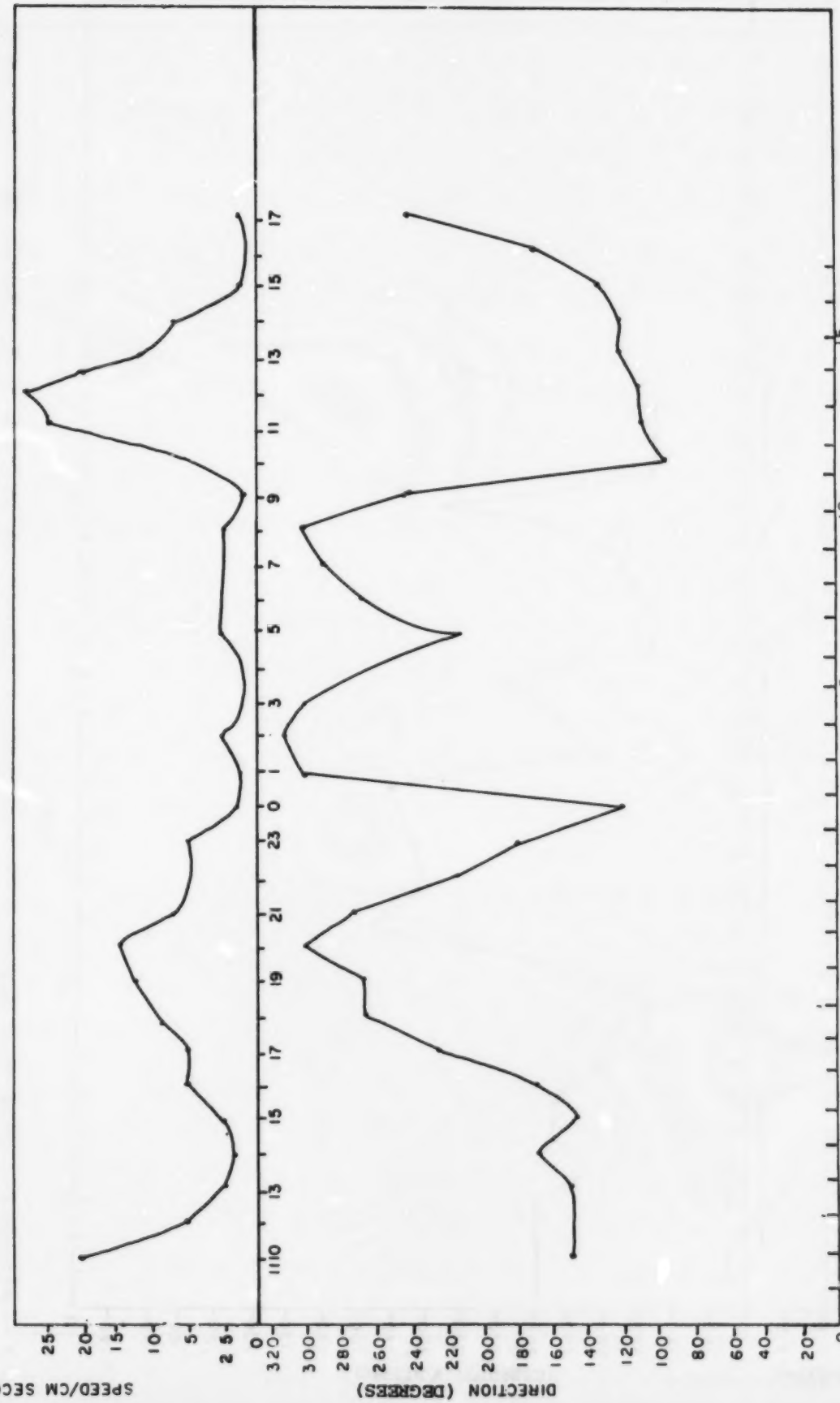

FIGURE 6 - DIRECTION AND VELOCITY OF SURFACE CURRENT AT STATION 5, BUCTOUCHE BAY

5.2 Salinity and Temperature

Table 2 gives a summary of the surface salinity and water temperature data collected during the survey period.

TABLE 2 SUMMARY OF SURFACE SALINITIES AND TEMPERATURE, BUCTOUCHE, AUGUST 6 - SEPTEMBER 25, 1976

STATION	SURFACE WATER TEMP C°		SURFACE SALINITY o/oo	
	MEAN	RANGE	MEAN	RANGE
1	16.6	14.2-19.5	19.2	13.8-21.9
5	17.3	14.8-23.6	20.4	16.5-23.0
8	20.9	13.8-22.1	23.0	20.4-25.1
14	17.7	15.0-20.9	22.7	21.5-23.8

Mean surface salinities rise approximately 3.5% between Station 2 and Station 4. There is no significant difference in temperature and salinity between surface and sub-surface samples indicating that the waters in the Bay are well mixed and non-stratified.

6 BACTERIOLOGICAL RESULTS

6.1 Comparison of A-1 and Standard MPN Methods

The A-1 method was used in this survey because it had been reported[3] and proved[7] that the A-1 method was as efficient as the standard MPN method in the recovery of fecal coliforms from shellfish growing waters. The A-1 method also had the advantage of speed and simplicity in analyses. The efficiency of the A-1 method in the recovery of fecal coliforms from Buctouche Bay was evaluated by comparison with the standard MPN method. Table 3 summarizes the parallel A-1 and standard MPN results obtained from the Buctouche Bay and streams. The percentage recovery of fecal coliforms by the two methods were comparable. The disparity between MPN values in both tests for most of the water tested was not significantly larger than discrepancies between results obtained with permissible variations of the standard dilution method. In comparing the 95% confidence limits of the standard MPN test with those of the A-1 method, it was found that the A-1 MPN fell within the confidence limits of the standard MPN 95.8% of the time.

6.2 Coliform Bacteria in Buctouche Bay

A total of 277 water samples were collected at 16 sampling locations in Buctouche Bay and at 22 tributaries. The results of fecal coliform and fecal streptococcus analyses on the samples are given in Table 2 and 3 of Appendix A. The distribution of median and maximum fecal coliform levels for the Buctouche Bay during the study period are presented in Figures 7 and 8.

TABLE 3 - COMPARATIVE RECOVERY OF FECAL COLIFORMS BY A-1 AND MPN METHODS

LOCATION	NO. OF SAMPLES	TEST	NO. OF TUBES INOCULATED	GAS POSITIVE TUBES NO.	GAS POSITIVE TUBES %
Buctouche Bay	50	A-1	750	97	12.9
		MPN	750	112	14.9
Buctouche Streams	37	A-1	555	443	79.8
		MPN	555	431	77.7
Total	87	A-1	1305	540	41.4
		MPN		543	41.6

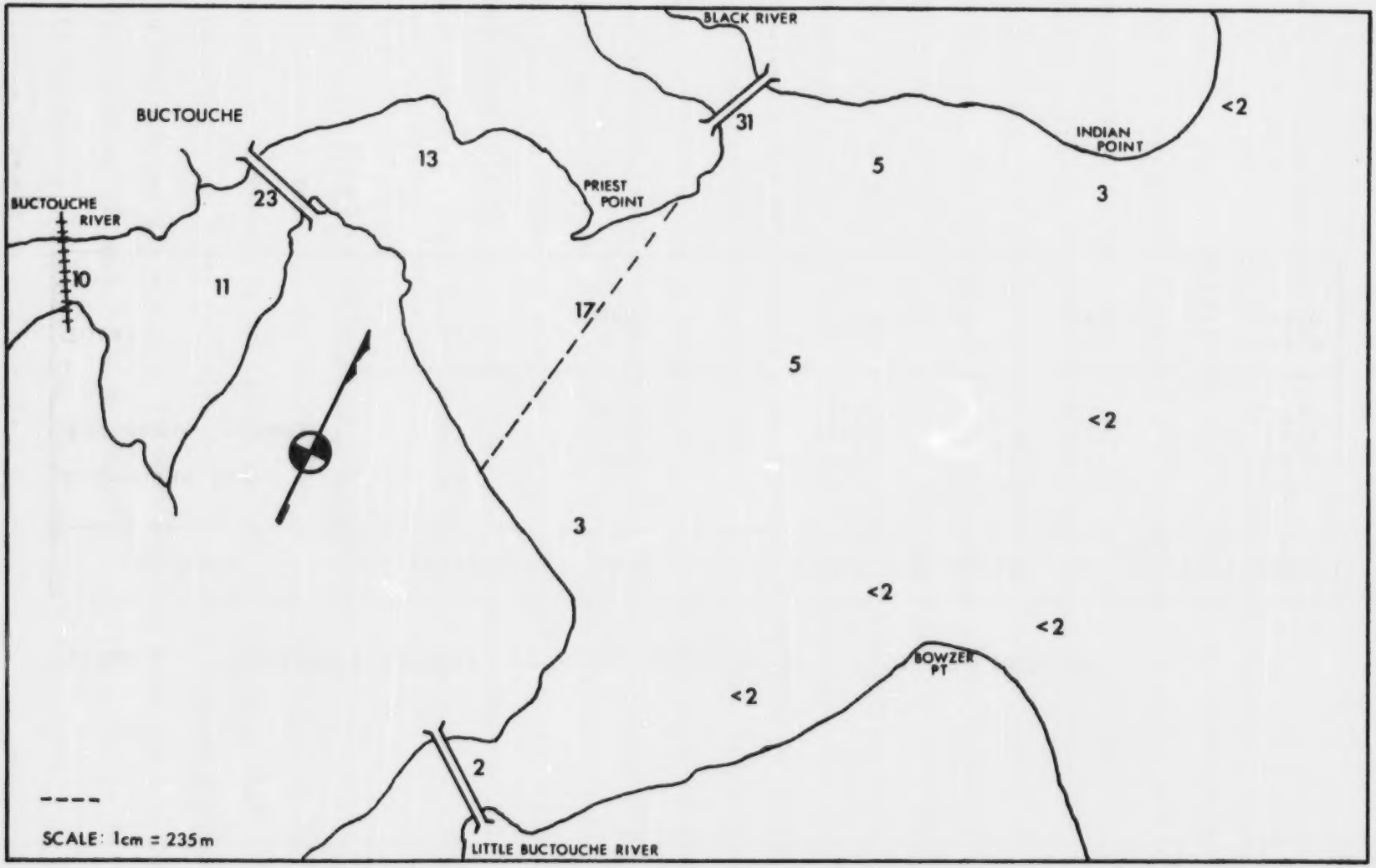

FIGURE 7 - DISTRIBUTION OF MEDIAN FECAL COLIFORM LEVELS IN BUCTOUCHE BAY, 1976

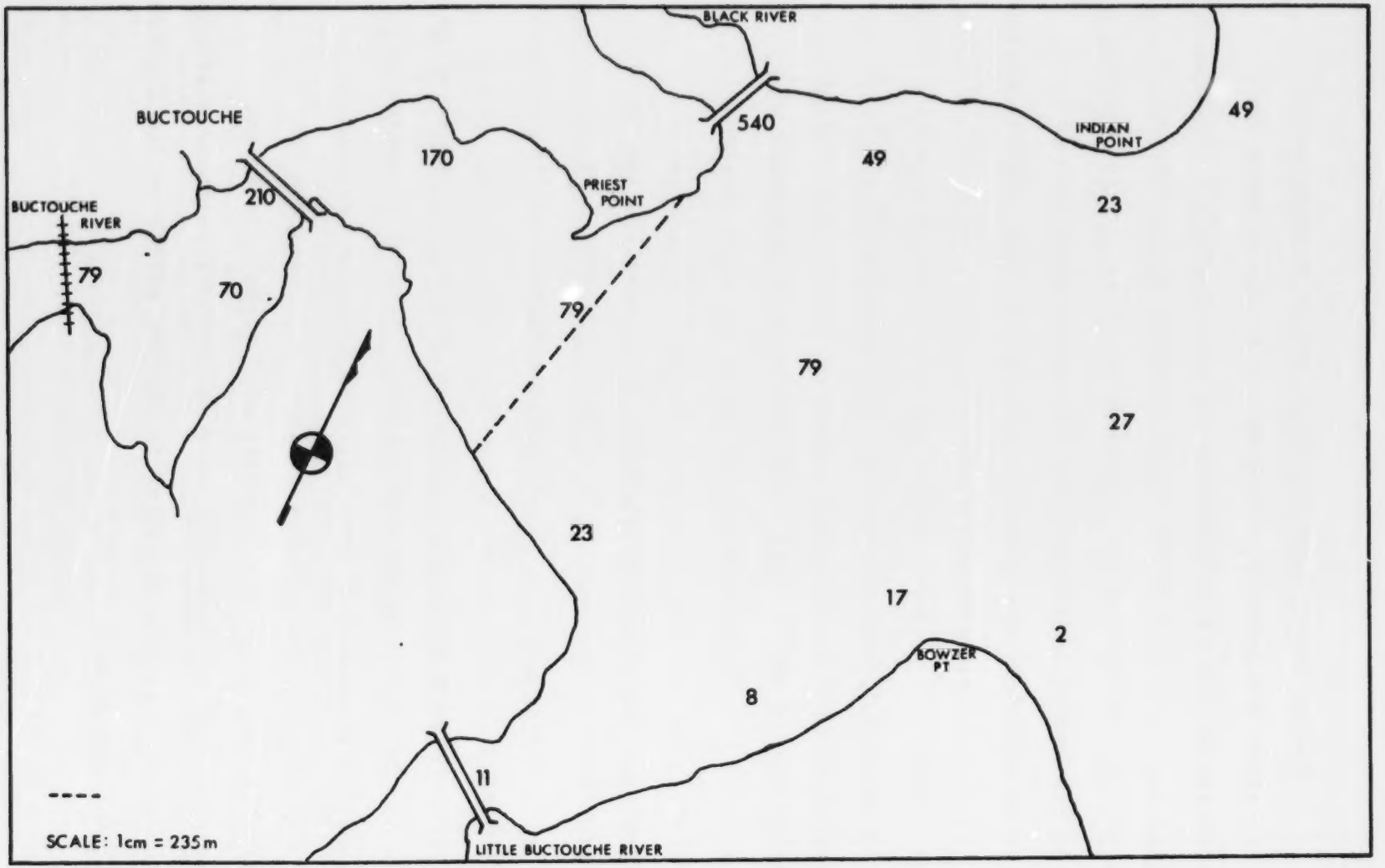

FIGURE 8 - DISTRIBUTION OF MAXIMUM FECAL COLIFORM COUNTS IN BUCTOUCHE BAY, 1976

Median fecal coliform levels of 14 were exceeded at only three stations (3, 5 and 6). Stations 3 and 5 are located inside the present boundaries of closure N.B. 6- 4. Station 6 is situated at the mouth of Black River (Figure 1). None of the stations in the approved shellfish growing waters (7-16) had median fecal coliform levels exceeding the 14 limit, also none of the stations had 10% of their samples greater than 43 fecal coliforms during the 1976 study. Distribution of fecal streptococcus densities in the Bay follow a similar pattern as the fecal coliform population. The majority of the fecal streptococcus counts were also observed in the five stations (1 to 5) within the closure, and station 6 at the mouth of Black River. Fecal streptococcus densities were generally negative in the sector of the bay approved for shellfish harvesting. The ratios between the fecal coliform and fecal streptococcus counts were usually greater than 2.0 which indicate that the source of fecal contamination in the bay was predominantly domestic sewage.

No Salmonella were recovered from any of the selected sites in the Buctouche Bay and estuary. Several suspected Salmonella colonies (20) were isolated from the stations inside the closure line; they were later all confirmed biochemically belonging to the genera of Proteus. It is not surprising that no Salmonella were recovered from these stations as the fecal coliform densities in the bay were very low throughout the study period.

6.3 Coliform Bacteria in the Watersheds

The concentration of fecal coliforms and fecal streptococci in the runoff waters from the streams varied greatly on different sampling dates. The variation was apparently caused by the intermittent nature of the pollution sources and the flow volume. Median fecal coliform densities in the streams ranged from 13 to greater than 2400 MPN and fecal streptococci ranged from 10 to 430 colonies per 100 ml of water samples (Table 4 & 5, Appendix A). Fecal coliform densities were generally very high in the watershed around Ste. Marie de Kent, Girouardville and McKee Mills. Highest fecal streptococcus densities were found at station 10 and 23 where a large number of cattle were observed.

The use of fecal streptococci in conjunction with fecal coliforms was first suggested by Geldreich[6] to indicate whether pollution is from human or nonhuman sources because the FC/FS ratio is always greater than 4 in domestic sewage effluents and generally less than 0.7 in animal wastes. Table 4 summarizes the relationship of a range of FC/FS ratio values to their respective probable origins.

TABLE 4 - RELATIONSHIP BETWEEN FC/FS VALUES AND POLLUTION SOURCES

FC/FS = X	INDICATIVE SOURCE OF POLLUTION
$X \geq 4$	Human wastes
$4 > X > 2$	Predominance of human wastes in mixed pollution
$2 \geq X \geq 1$	Uncertain of interpretation
$1 > X > 0.7$	Predominance of animal wastes in mixed pollution
$0.7 \geq X$	Livestock or poultry wastes

In an effort to evaluate the FC/FS ratios for comparison with the relationships set forth in Table 4, a percentage occurrence of fecal coliform from various sources was prepared in Table 5. It is quite apparent from Table 5 that fecal bacteria in the upper section of Buctouche River originated from both domestic and animal wastes. From Buctouche downstream to the bay, the source originated primarily from domestic sewage. The source of fecal coliforms at Girouardville originated primarily from livestock. These data emphasize the importance of defining non-point sources of pollution in additional to point sources when assessing the bacterial quality of streams.

The contribution of fecal pollution by watershed runoff to Buctouche River estuary was determined by the quality of fecal coliforms discharged per unit drainage calculated from the flow of the stream and bacterial concentration. The average flow obtained during the study period ranged from 0.99 cubic feet per second (cfs) at Girouardville to 279.3 cfs at Coates Mills. The rate of fecal coliforms discharged from these two sources to the Buctouche River were calculated at 6.2×10^{10} fecal coliforms per day and 8.7×10^{11} fecal coliforms per day respectively. Although the flow at the Black River was only moderate (25.6 cfs) the volume of fecal coliform discharge at the upper sector of the river (station 16) was highest (1.6×10^{12} FC/day) among the streams studied. However, the numbers of fecal coliform discharge were reduced to 1.5×10^{10} fecal coliforms per day as it reached the bay

TABLE 5 PERCENTAGE OF TIME FECAL BACTERIA FROM VARIOUS SOURCES IN THE BUCTOUCHE RIVER WATERSHEDS

LOCATION	HUMAN (%)	PREDOMINANTLY HUMAN (%)	INDETERMINABLE (%)	PREDOMINANTLY (%)	ANIMAL (%)
Coates Mills	16.7	33.3	16.7	16.7	16.7
Ste-Marie de Kent	60.0	6.7	26.7	0	6.7
Girouardville	0	12.5	25.0	0	62.5
Black River	45.5	36.4	0	9.1	9.1
McKee Mills	40.0	10.0	20.0	10.0	20.0
Buctouche	50.0	0	50.0	0	0
Buctouche Bay	44.8	16.4	13.4	19.4	6.0

(Station 17). This study indicates that the contribution of watershed runoff in the fecal coliform pollution to Buctouche River was substantial. A large volume of estuarine water is needed to dilute fecal coliform discharged from the watershed to less than 14 fecal coliform MPN per 100 ml, the approved water quality standard for shellfish harvesting. For example, it would have required $6.2 \times 10^4 M^3$ of estuarine water per day to dilute the fecal coliform discharge from Coates Mill to less than 14 MPN per 100 ml assuming complete mixing. Thus, it is easy to see that the receiving capacity of the upstream portion of the Buctouche Harbour and River will be quickly exceeded during periods of high fecal coliform discharge, such as September 3 and 24. The receiving capacity of the outer portion of Buctouche Bay (approved section) would not be exceeded as quickly because of better mixing and greater dilution factors. Examination of the data in Figure 7 indicates that this is the case, fecal coliform densities decrease continuously as the waters move downstream from the river to the bay. Fecal coliform levels beyond station 5 are generally less than 14 MPN per 100 ml.

6.4 Verification of Fecal Coliform Isolates

To determine the sanitary significance of the fecal coliform counts in the study area, a total of 120 colonies were isolated from gas-positive A-1 tubes and subjected to biochemical identification. Verification of fecal coliform isolates indicates that 81% of the isolates from Buctouche Bay are *E. coli* biotypes 93.6% of the isolates from the streams are *E. coli* types. The high percentages of *E. coli* recovered from these samples

concurrent with the high FC/FS ratios indicates that the majority of the fecal contamination in the Bay is from domestic wastes.

7 RAINFALL - FECAL COLIFORM RELATIONSHIP

The data available following periods of high rainfall is limited. The 1976 survey data for three major precipitation events of 0.5, 0.5 and 0.88 inches per 24 hr. period includes data for 24 hr. period following these events. The most significant storm observed in the area, 2.56 inches in 24 hrs., occurred in September, 1975 and only 72-120 hr. data is available (Baxter and Julien, 1976). As it is necessary to utilize all of the available information to derive an estimate of the expected response of fecal coliform levels to rainfall the expected 24 hr. counts following the 1975 storm or 2.56 inches have been extrapolated as shown in Figure 9.

Median fecal coliform level - time data was plotted and regression lines were fitted by the least squares method. Thus from Figure 9 we have utilized the predicted 24 hrs. fecal coliform levels for the open and closed area in our final analysis. We have some confidence in the validity of this approach due to the fact that the plotted responses appear linear through the 24-120 hour period and that the slope of the 24-72 hour response is very similar to the observed slope of the 72-120 hour response as measured for identical sectors on separate storm events. Figure 9 shows the regression lines calculated for all the observed 24 hr. median fecal coliform levels and the extrapolated values vs rainfall.

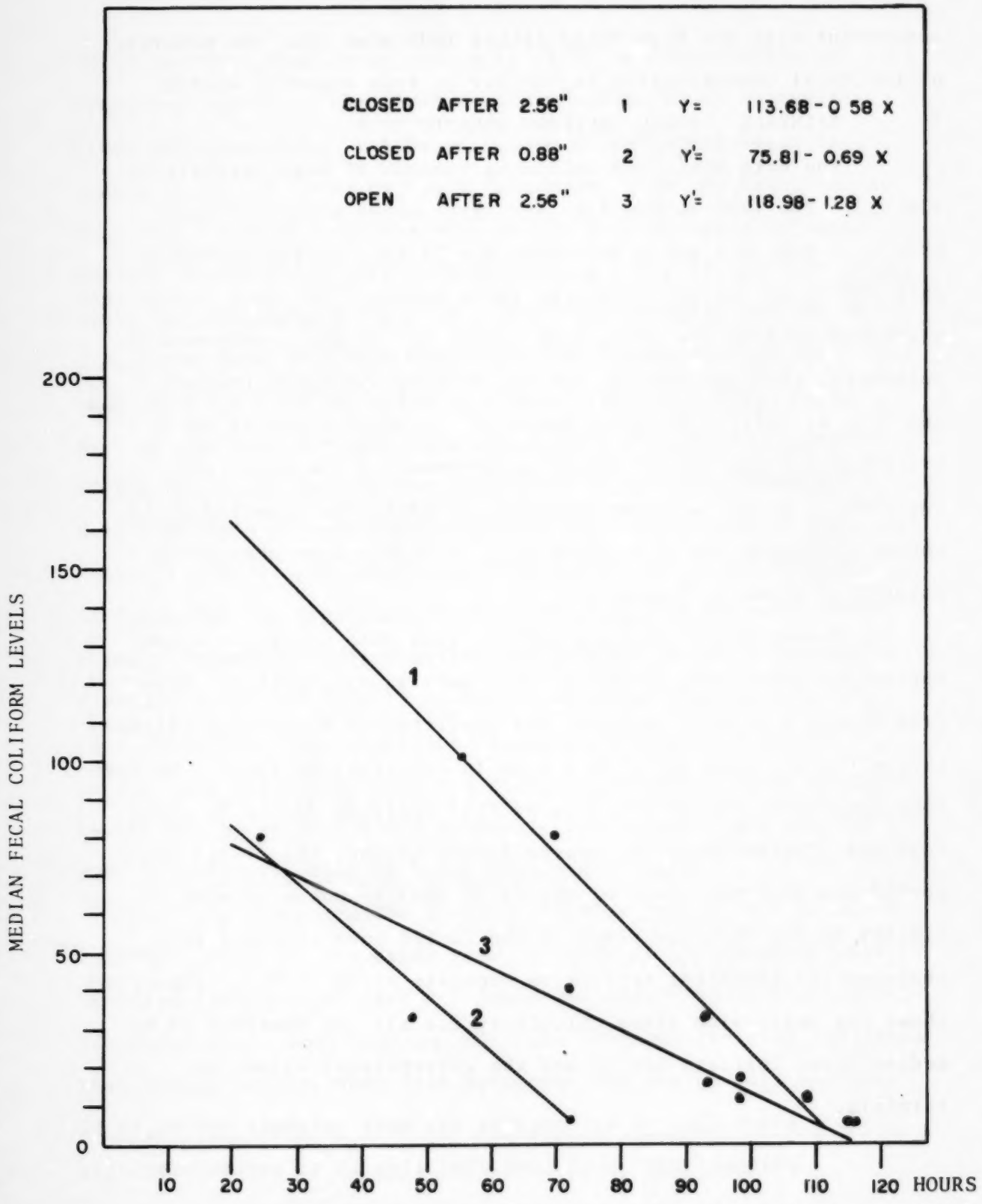

FIGURE 9 - REGRESSION ANALYSIS OF FECAL COLIFORM LEVELS AND RAINFALL

This Figure gives the fitted relationship of median fecal coliform levels and rainfall for the closed sector (Stations 4-5), immediately above the present closure line and for the open harvesting area (Stations 8, 9, 11, 12). From Figure 10 it can be seen that the closed area has median fecal coliform levels which approach 14 under conditions of little or no rainfall. The open sector, however, can be expected to exceed a median value of 14 following approximately 0.9 inches of rain in 24 hrs. This rainfall level then represents the criteria on which the currently open growing area should be closed.

The other important aspect of the fecal coliform level response to rainfall is the time of return to pre-rainfall conditions. Figure 11 presents approximated return-time curves for the open and closed sectors. It is apparent that the time required for fecal coliform levels to return to a median 14 are only slightly less in the open area than in the closed sector. Generally for both sectors the time of return for maximum 24 hr. rainfalls equal to or less than 2.75 inches (95% probable) is approximately 4 to 4.5 days. Thus under the worse 24 hr. rainfall conditions which can be reasonably expected fecal coliform levels in both sectors will have returned to background levels after 120 hrs.

Comparison of the open and closed areas in terms of their dynamics with regard to rainfall response proves useful. Bacteria levels in response to rainfall are higher and rise at lower total 24 hr. rainfall in the closed or river sector than the Bay (or

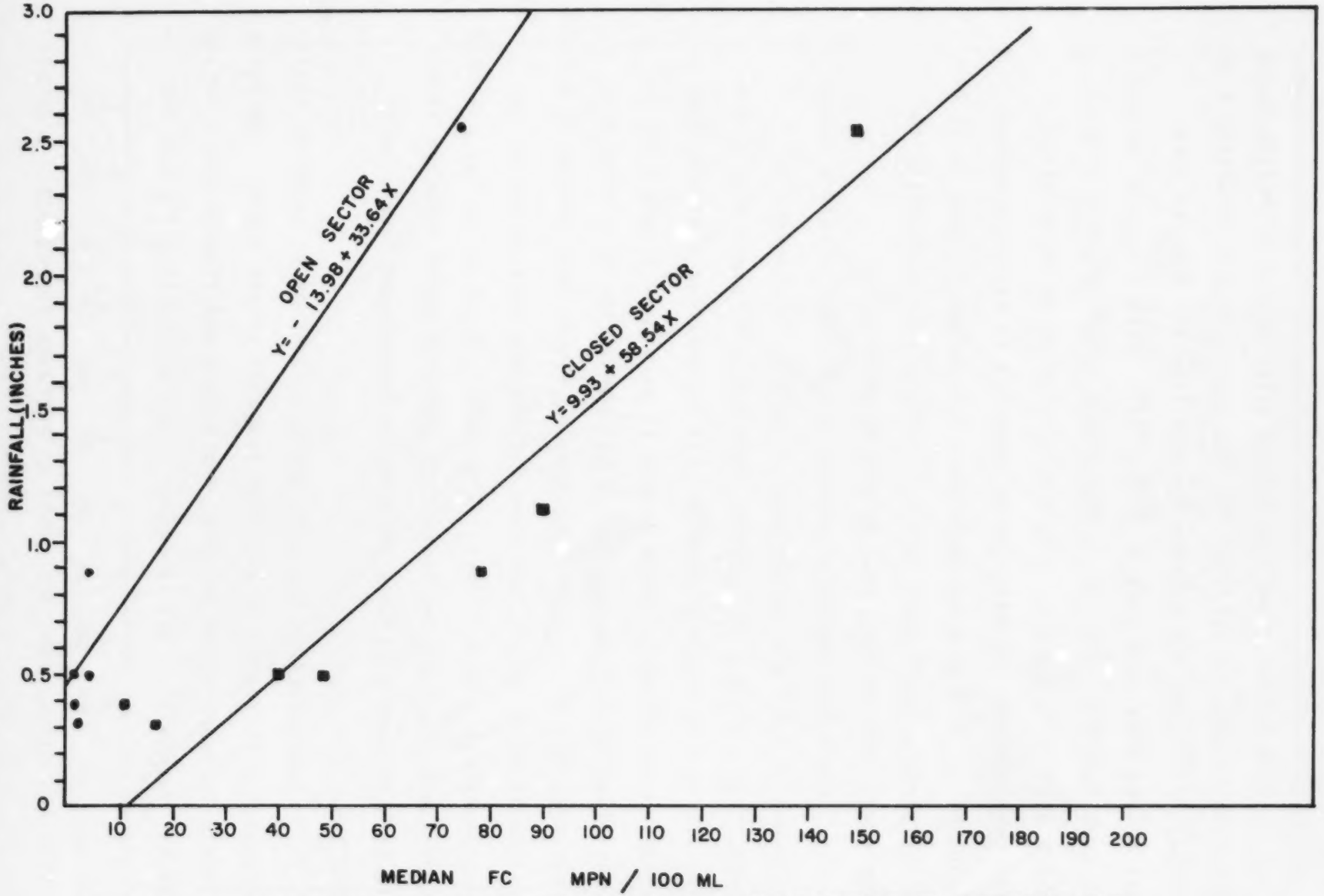

FIGURE 10 - RELATIONSHIP OF FECAL COLIFORM LEVELS AND RAINFALL IN BUCTOUCHE BAY

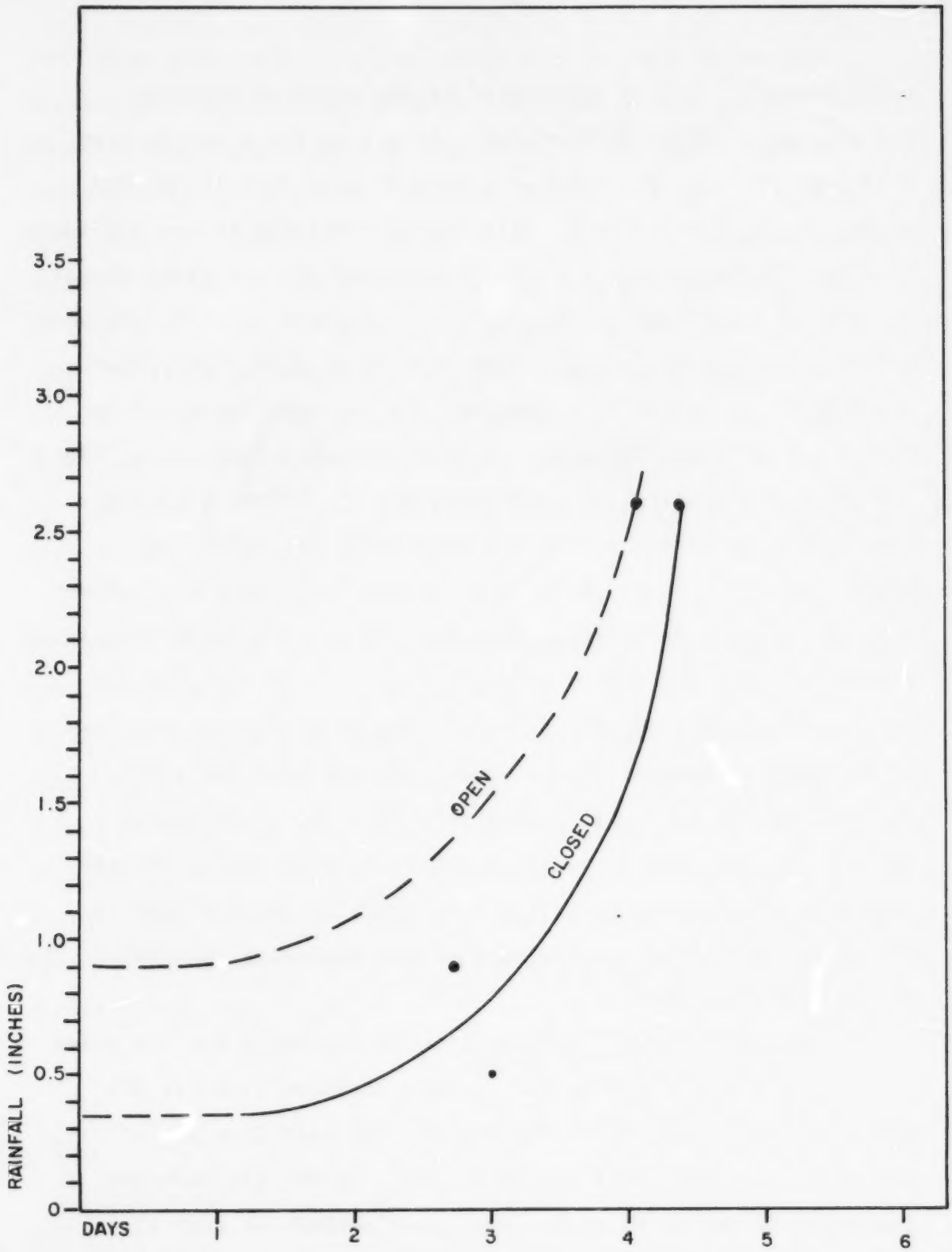

FIGURE 11 - TIME OF RETURN TO FECAL COLIFORM LEVEL OF 14
(ESTIMATED APPROXIMATE CURVES)

open) sector. This is explicable on the basis of relative volumes and dilution differences. Levels on the river section following rainfall decrease at a greater rate than in the Bay Sector (Figures 9 and 10). This can be explained if one considers that the contamination is of fresh water origin and given normal stratification of fresh water in the river, the rate of transport of contamination through the river sector is much higher than in the Bay. Thus levels fall quicker. In the Bay contamination is subject to more mixing and is thus entrained relatively longer and the Bay also receives a great volume of contaminated water than the river sector due to the additional discharges of the Black and Little Buctouche Rivers. These facts lead to a slower rate of bacteria decrease in the Bay. The latter point concerning the greater volume of contamination reaching the Bay also may explain the increased rate of rise in bacterial levels observed in the Bay as shown in Figure 10 as compared with the river sector. To summarize it appears from the present data that the rate of increase in bacteria levels is more rapid but peak densities are lower after greater rainfall in the Bay than in the river sector and decline more slowly following rainfall.

8 CONCLUSIONS

Bacteriological water quality of Buctouche Bay was quite variable and rainfall dependent. Data compiled from all the surveys conducted in Buctouche Bay for the last five years indicates that the fecal coliform levels in the Bay increase dramatically for up to three days after periods of very high rainfall (2.56 inches). The approved sector of the Bay generally

have very good bacteriological water quality and the median fecal coliform levels are usually less than 14 MPN per 100 ml. However, it is expected that some parts of the approved area could have fecal coliform counts greater than 43 MPN following more than 0.7 inches of rainfall in 24 hours. Although a median value of 14 may not be exceeded except at higher rainfall levels (0.9/24 hrs.), this is arrived at from the regression analyses of fecal coliform and rainfall data compiled from the previous surveys. The data of the present survey shows that bacteriological water quality of the sector of the Bay beyond Station 5 are satisfactory for approved shellfish harvesting, even following 0.88 inches of rain in 24 hours.

The watershed runoff may contribute substantial quantities of fecal coliforms to the Buctouche estuary. The majority of the fecal pollutants are transferred from the river to the Bay on a falling tide along the channel and disperse as it reaches the open bay. Therefore, unsatisfactory bacteriological quality is often found in the river and inner harbour during the period of heavy flow. Fecal coliform densities have diluted substantially as they reach the Bay so that they have a reduced effect on the bacteriological water quality of the oyster beds in the approved sector of the Bay.

The closures for the Buctouche Bay and the Little Buctouche River recommended in the 1975 survey[4], are adequate and should be retained. It should be pointed out, however, that the oyster beds in the approved sector of the Bay may be slightly contaminated in the event of heavy rainfall greater than 1 inch in 24 hours. Therefore, it is advisable to refrain from harvesting these beds for seven days after extremely high rainfall. It is also concluded that the portion of Black River above the highway 505 bridge must be closed for direct shellfish harvesting (Figure 1).

Serious consideration should be given to the need for a conditional closure encompassing the currently approved leased portions of Buctouche Bay. If it is felt that such a closure is required the following closure and reopening criteria should be applied:

1. The leased area outside the present closure should be closed following one (1.0) inch of rainfall in 24 hrs. and following 1.5 inches of rainfall in 48 hours.
2. The conditional closure should remain in effect for a minimum of 7 days.

We have not recommended the implementation of a conditional closure for two reasons. First,fecal coliform levels in excess of current standards following major storms is not a phenomenon which is unique to Buctouche Bay. Experience suggests that this commonly occurs in many other currently approved areas in the Maritimes. Secondly, fecal coliform levels observed in Buctouche Bay following storms are relatively moderate when compared with the observations from other growing areas under similar

conditions of rainfall. On the other hand there is concern over the public health implications of such levels,in this situation, due to the undesirable sanitary conditions which prevail on the drainage basin.

9 RECOMMENDATIONS OF THE MARITIME STANDING COMMITTEE ON SHELLFISH

The closure on Buctouche Bay and the Little Buctouche River recommended in the 1975 survey are adequate and and should be retained. A new closure on the Black River should be implemented as shown in Figure 1 of this report.

It was concluded that a conditional closure on Buctouche Bay based on a rainfall criteria as proposed in this report (Figure 12) would be acceptable if an adequate and practical control procedure can be developed.

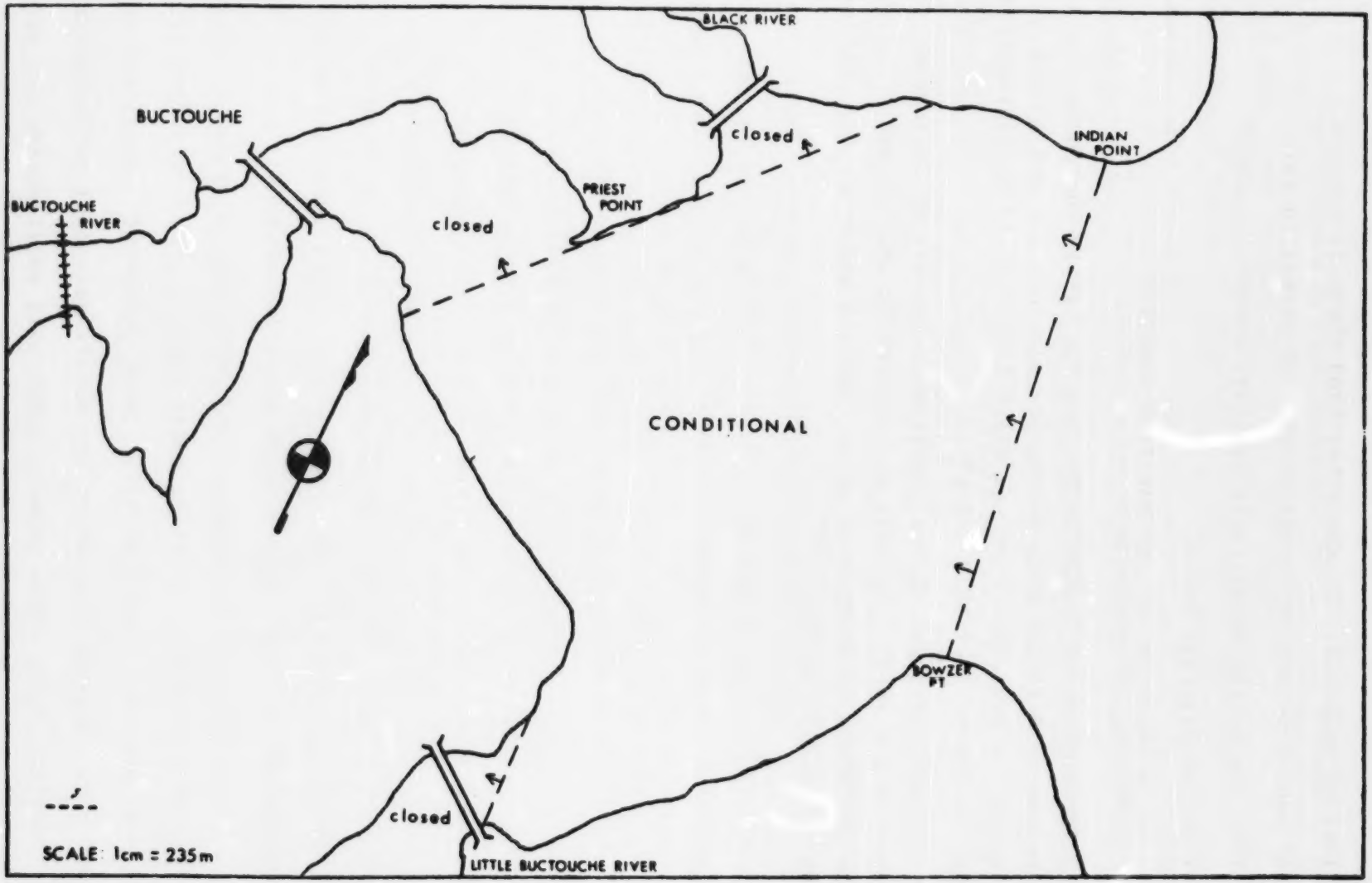

FIGURE 12 MAP OF SURVEY AREA SHOWING A SUGGESTED CONDITIONAL CLOSURE

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APPENDIX

TABLE A-1 PRECIPITATION DATA AND TIDAL STAGE FOR THE BUCTOUCHE AREA DURING THE STUDY PERIOD, 1976

DATE		PRECIPITATION (INCH)	SAMPLING DAYS	TIDAL STAGE AT SAMPLING TIME
Aug.	3		*	Low Rising
	6	.11	*	High Falling
	8	.05		
	9	.09	*	Low Rising
	10	.31		
	11	.29	*	High Falling
	12	T		
	13	T	*	High Rising
	14	.22		
	15	.15	*	High Rising
	16	.5	*	Low Falling
	17		*	Low Falling
	18	.04	*	Low Falling
	23		*	Mid Rising
	26	T		
	27	T		
	28	.08		
	29	.03		
	30	.39		
	31		*	Low
Sept.	2	.5	*	Low Rising
	3		*	High Falling
	4		*	High Falling
	5	T		
	8		*	High Rising
	9	.02		
	13	.35		
	15		*	Low-Mid Rising
	20	.50		
	22	.88		
	23		*	High Falling
	24		*	High Rising
	25		*	Low-Mid Rising
	27	.64		

TABLE A-2 FECAL COLIFORM DATA, BUCTOUCHE BAY, N.B., 1976

DATE	STATION															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Aug. 3	8	5	8	2	23	13	5	<2	2	2	<2	2	<2	<2	8	2
Aug. 6	8	4	23	2	17	<2	5	5	<2	<2	<2	<2	5	<2	<2	2
Aug. 9		5		23	33		49	79	<2	<2	2	<2	5	<2	<2	<2
Aug. 11 A.M.		2		13	13		7	17	<2		2	<2	5	<2	<2	2
Aug. 11 P.M.		14		33	21		5	22	4		<2	<2	4	<2	<2	<2
Aug. 13		9		9	17		<2	4	2		<2	4	<2	2	27	<2
Aug. 15		17		17	22		2	2	23		8	2	4	<2	<2	<2
Aug. 16		<2		17	33		4	13	23	<2	<2	4	23	2	11	<2
Aug. 17	79	14	33	33	46	130	4	2		4	7	<2	4	8	<2	<2
Aug. 18	17	17	23	13	11	70	<2	13	14	<2	7	4	<2	<2	13	<2
Aug. 23	11	36	23	23	11	46	<2	6		11	6	<2	<2	<2	<2	2
Aug. 31	14	22	23	11	9	79	5	5	5	5	<2	<2	<2	2	<2	<2
Sept. 2	11	13	11	14	8	21	13	11	8	2	2	2	6	11	2	<2
Sept. 3	17	14	210	170	49	40	<2	5	<2	2	2	2	<2	2	<2	<2
Sept. 4	5	2	17	33	33	22	2	2	2	<2	<2	<2	2	<2	2	<2
Sept. 8	8	8		5	5			2		4						
Sept. 15	7	6	4		7	540		8		4						
Sept. 23	8	70	2	13	79	31	4	2	2	2	8	5	2	49	<2	<2
Sept. 24	49	33	23	33	33	21	5	<2	14	7	<2	17	11	8	2	<2
Sept. 25	2	2	13	8	5	2	<2	<2	11	5	<2	<2	<2	<2	<2	<2
Median	10	11	23	13	17	31	5	5	3	2	<2	<2	3	<2	<2	<2
%>43	14.3	5.0	7.7	5.3	15.0	38.5	5.6	5.0	0	0	0	0	0	5.6	0	0

TABLE A-3 FECAL STREPTOCOCCUS DATA IN BUCTOUCHE BAY, N.B., 1976

STATION NO.	AUG. 18	AUG. 23	AUG. 31	SEPT. 3	SEPT. 4	SEPT. 8	SEPT. 23	SEPT. 24	MEDIANS
1	10	6	8	4	2	10	<2	2	5
2	6	4	6	4	<2	8	10	6	6
3	2	2	4	60	4		20	2	4
4	4	2	2	36	2	10	10	6	5
5	2	2	<2	24	2	12	<2	<2	2
6	2	4	10	6	<2		24	2	4
7	<2	2	4	<2	<2		2	2	2
8	2	<2	<2	2	2	2	2	4	2
9	2		4	2	2		2	<2	2
10	<2	<2	2	<2	<2	<2	10	<2	<2
11	2	12	2	2	<2		2	<2	2
12	<2	22	<2	<2	<2		<2	4	<2
13	<2	2	<2	<2	<2		2	4	<2
14	<2	<2	2	<2	<2		<2	2	<2
15	<2	<2	2	<2	2		<2	<2	<2
16	<2	<2	<2	2	<2		2	<2	<2

TABLE A-4 FECAL COLIFORM DATA IN STREAMS, BUCTOUCHE, N.B.

DATE	STATIONS											
	1	2	3	4	5	6	7	8	9	10	11	12
August 4	33	240	79	79	49	>2400	920	110	>2400	49	33	79
9		240	49	79	70	350	920	540	540	220	920	46
11 AM	110	170	>2400	170	1600	79	>2400	>2400	>2400	1600	>2400	33
11 PM	920	540	1600	>2400	>2400	540	>2400	1600	>2400	>2400	1600	240
13	21	920	79	33	79	49	1600	350	>2400	130	350	13
15	240	>2400	920	350	>2400	>2400	>2400	540	>2400	920	1600	540
16	350	1600	>2400	>2400	350	1600	>2400	1600	1600	>2400	>2400	350
17	21	240	540	33	110	170	1600	920	1600	350	350	
18	6	22	70	11	46	21	540	350	350	540	170	
23	2	140	540					240		920		34
30	>2400	>2400	540					70		1600		
Sept. 1	1600	>2400	120					220		540		
3	27	170	49					130		240		
4	49	920	49					110		49		
23	280	920	350					350		350		
24	13	130	49					46		49		
25	27	49	70					280		79		
MEDIAN	41	240	120	79	110	350	1600	350	>2400	350	920	63

TABLE A-4 (Cont'd) FECAL COLIFORM DATA IN STREAMS, BUCTOUCHE, N.B.

DATE	STATIONS										
	13	14	15	16	17	18	19	20	21	22	23
August 4	130			920		1600					
9	8	1600			2	>2400	540	920	130	5	
11 AM	180	>2400	>2400	>2400	23	>2400	170	>2400	920	23	
11 PM	130	>2400	>2400	>2400	9	>2400	1600	>2400	920	<2	
13	26	130	1600	1600	8	>2400	79	>2400	220	4	
15	49	>2400	920	>2400	49	>2400	1600		540	46	
16	7	>2400	>2400	>2400	>2400	1600	240	>2400	>2400	13	
17		350	1600		540	540	220	920	920		
18		110	1600	920	240	350	130	350	79		1600
23	920	130		>2400	17	540	920	920	540	920	>2400
30		>2400		>2400	17	>2400	350	920	>2400		>2400
Sept. 1		1600		>2400	49	>2400	540	1600	>2400		>2400
3		110		920	23	240	49	540	350		920
4		31		430	23	1600	>2400	350	49		240
23		70		70	130	>2400	920	920	170		>2400
24		46		>2400	8	220	540	540	1600		79
25		240		70	280	23	350	33	220		170
MEDIAN	90	285	1600	>2400	23	1600	445	920	540	13	1600

TABLE A-5 FECAL STREPTOCOCCUS DATA IN STREAMS, BUCTOUCHE, N.B., 1976

STATION NO.	AUG. 4	AUG. 18	AUG. 23	AUG. 30	SEPT. 3	SEPT. 4	MEDIANS
1	26	12	100	850	30	24	28
2	74	130	490	1600	280	110	205
2A		1400	380	2200	120	430	430
3	18	70	280	200	230	22	135
4	34	32					33
5	14	88					50
6	98	74					85
7	98	180					140
8	70	46	50	66	18	10	48
9	64	120					90
10	1900	310	1300	400	150	10	350
11	24	260					140
12			28				28
13			210				210
14	120	200	200	2000	200	66	200
15	86	420					250
16	180	270	490	1400	150	150	230
17		6	38	10	10	<2	10
18	90	170	410	1000	160	140	160
19		160	470	550	140	140	160
20		100	210	650	110	36	110
21		100	130	1200	90	66	100
22			38				38